

**NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION**

**MATERIALS AND RESEARCH
DIVISION**

Experimental Study ND 2000-02

3M Stamark™ Liquid Pavement Markings

Final Report

Project ACNH-1-083(058)111

August 2002

Prepared by

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

BISMARCK, NORTH DAKOTA

Website: <http://www.discovernd.com/dot>

DIRECTOR

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MATERIALS AND RESEARCH DIVISION

Ron Horner

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT	EXPERIMENTAL PROJECT NO.					CONSTRUCTION PROJ NO	LOCATION
	STATE	YEAR	-	NUMBER	SURF	ACNH-1-083(058)111	McLean County
	1	ND	2000	02		8	28
	EVALUATION FUNDING					NEEP NO.	PROPRIETARY FEATURE?
	1	X	HP&R	3	DEMONSTRATION		X Yes
	48	2	CONSTRUCTION	4	IMPLEMENTATION	49	51 No
SHORT TITLE	TITLE 3M Stamark Liquid Pavement Markings						
	52						
THIS FORM	DATE	MO.	YR.	REPORTING			
	140	0	8	-	0	2	1 INITIAL 2 ANNUAL 3 X FINAL
KEY WORDS	KEY WORD 1				KEY WORD 2		
	145 PAINT				167 LUMINAIRES		
	KEY WORD 3				KEY WORD 4		
	189				211		
	UNIQUE WORD				PROPRIETARY FEATURE NAME		
	233 MICROCRYSTALLINE CERAMIC BEADS				255 STAMARK		
CHRONOLOGY	DATE WORK PLAN APPROVED:		DATE FEATURE CONSTRUCTED:		EVALUATION SCHEDULED UNTIL:		DATE EVALUATION TERMINATED:
	07-00		09-00		10-05		5-02
	277		281		285		289
QUANTITY AND COST	QUANTITY OF UNITS			UNITS			UNIT COST (Dollars, Cents)
	12685			1 X LIN. FT 5 TON 2 SY 6 LBS 3 SY-IN 7 EACH 4 CY 8 LUMP SUM			0.86
	297			305			306
AVAILABLE EVALUATION REPORTS	CONSTRUCTION		X PERFORMANCE			X FINAL	
	315						
EVALUATION	CONSTRUCTION PROBLEMS				PERFORMANCE		
	1 NONE 2 X SLIGHT 3 MODERATE 4 SIGNIFICANT 318 5 SEVERE				1 EXCELLENT 2 GOOD 3 SATISFACTORY 4 X MARGINAL 319 5 UNSATISFACTORY		
APPLICATION	1 ADOPTED AS PRIMARY STANDARD 2 PERMITTED ALTERNATIVE 320 3 ADOPTED CONDITIONALLY				4 X PENDING (Explain in remarks if 3, 4, 5, or 6) 5 REJECTED (is checked) 6 NOT CONSTRUCTED		
REMARKS	321 Initial retroreflectivity readings were higher than conventional water based paint but lower than manufacturer claims. The experimental test section was remarked with a water based paint before the second evaluation. Because the experiment had been compromised it will be terminated.						
	700						

Experimental Study ND 2000-02

**3M™ STAMARK™ Liquid Pavement Marking
Series 1200 Verses Water Based Paint**

Final Report

ACNH-1-083(058)111

August 2002

Written by
Dean Schloss/Steven Henrichs

Disclaimer

The contents of this report reflect the views of the author or authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views of the North Dakota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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3MTM STAMARKTM Liquid Pavement Marking Series 1200 Verses Water Based Paint

Objective

Water based paint pavement markings deteriorate quickly and are commonly remarked annually. The North Dakota Department of Transportation needs a cost effective long-term pavement marking system that lasts longer than the available water based paints. The objective of this study was to determine if 3M Stamark Liquid Pavement Marking Series 1200 is a cost effective and more durable alternative than presently used water based paint.

Location

This experimental project was incorporated into project ACNH-1-083(058)111. The project is located on the U.S. Highway 83 northbound roadway between Wilton and Washburn. The Series1200 liquid paint marking begins at mile point 127.3 and ends at 128.3.

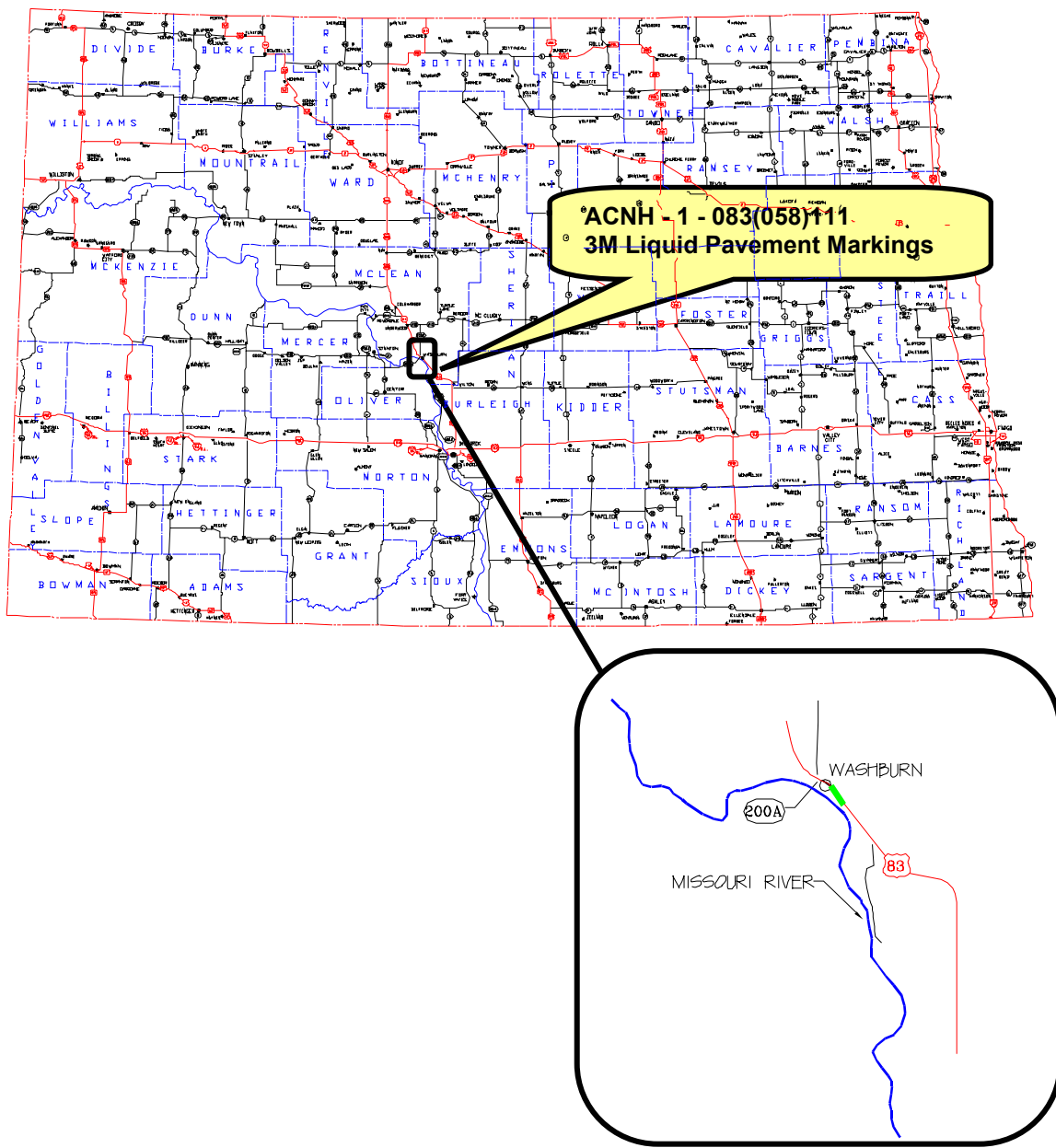


Figure 1 - Project Location.

Project History

Traffic data

The one-way traffic for the northbound roadway is shown in Table 1.

Year	Passenger Car	Trucks	Total	30TH Max Hr	*Flexible ESALs
1998	2,670	280	2,950	300	210
2002	1,988	263	2,250	225	210

*The flexible ESALs stayed constant because the truck ESAL factor changed from .75 in 1998 to .8 in 2002.

Table 1

Roadway Information Management System (RIMS) data

The construction history of the northbound roadways is shown in Table 2.

Year	Thickness	Type	Width
1981		Grade	48'
1981	8.0"	Aggregate Base	37'
1981		C-C 84 feet	
1981	2.0"	Aggregate Base	37'
1982	2.0	Recycled Hot Bit Pavement - 200-300	30'
1982	1.5"	Hot Bit Pavement - 120-150	27'
1991	-0.8"	Milling	27'
1991	2.5"	Hot Bit Pavement	27'
1994		Intermittent Cont Patch 1.25"	27'
1995		Chip Seal	40'
2000	5.0"	Aggregate Base	38'
2000	16.0"	Blended Base	30'
2000	3.5"	Hot Bit Pavement	35'
2000	2.0"	Hot Bit Pavement	35'

Table 2

Design

The plans show that the water based paint markings are to be applied in accordance to section 762 of the *1997 North Dakota Department of Transportation Standards for Road and Bridge Construction*. The 3M™ Stamark™ Liquid Pavement Marking Series 1200 was substituted into the project in place of the water based paint, for a one mile segment beginning at Mile Point 127.3 and ending at 128.3. The experimental section consisted of one mile of white and yellow continuous edge line and white centerline skips.

Material

The following statements are from the manufacturer's literature.

The binder for Series 1200 marking is a two-component, 100% solids polyurea coating material, which rapidly cures to hardness after application. High initial and long-term reflectivity is provided by a combination of reflective elements and glass beads, both dropped onto the binder just after it is coated and before it hardens. The reflective elements have a ceramic core and long lasting, high index, microcrystalline ceramic beads partially embedded onto their surface. Factory controlled manufacture of the elements ensures consistent retroreflective performance. Series 1200 liquid marking resists color change from UV exposure, and will provide long-term performance on both asphalt and Portland cement concrete.

When applied to manufacturer's recommendations, Series 1200 markings have initial retroreflectance values of 1200-1400 for white and 700-850 for yellow. This is in accordance with testing procedures of ASTM D4061. An observation angle of 1.05E and an entrance angle 88.8E correspond to 30 meter geometry. The life of the series 1200 paint is projected to last 3 to 4 years.

Construction

The yellow and white striping was painted on September 8, 2000. Traffic Safety Services, Inc. was the contractor for this project. A truck mounted, self contained pavement marking machine was used for the application process. The marking machine was designed to apply the two-component liquid materials, glass beads and the reflective elements in a continuous or skip line pattern. The experimental section is located on US Highway 83 between reference point 127.3 and 128.3 in the northbound lane. The control section is located to the north and south of this segment.

Once the installation of the Series 1200 pavement marking was completed a noticeable difference was seen when compared to the water base paints. The 1200 series paint was brighter in the white and yellow applications. Photos 1 and 2 show a comparison between the water base paint and the Series 1200 paint.



Photo 1 - Left half of photo is water based paint and the right half of photo is Series 1200 paint.



Photo 2 - Left half of photo is Series 1200 paint and the right half of photo is water based paint.

A problem that was noticed was due to the application process. As can be seen in photo 3, there is a large amount of over spray that occurred.



Photo 3 - Over spray.

Also very noticeable was the presence of the ceramic beads. Photo 4 shows the Series 1200 paint slightly magnified. The larger masses in the photo are the reflective ceramic beads. The water base paint does not contain ceramic beads but they both have standard glass beads. The purpose of the ceramic beads is to provide high initial and long-term reflectivity.



Photo 4 - Magnification of Series 1200 paint.

Evaluation

The first evaluation was conducted on January 11, 2001. Several reflective readings were taken with a 30 meter geometry testing device (LTL 2000) which had a 88.8E entrance angle and a 1.05E observation angle. The average reflected luminance (R_L) for the Series 1200 paint, water base paint, and reflective tape can be found in Table 3.

Reflected Luminance (R_L)				
Type	White		Yellow	
	Average	Std Dev	Average	Std Dev
3M Stamark 1200 - 4"	391	176	269	109
Water Base - 4"	276	34	135	41
Centerline Skip 3M Stamark 1200 - 4"	365	100	N/A	N/A
Centerline Skip Tape	901	28	N/A	N/A

Table 3

A further break down of the readings can be found in Appendix A and B. The 3M Stamark Liquid Pavement marking readings are lower than expected and also lower than the manufacturer's R_L range. The expected values as determined by the manufacturer should be around 1200-1400 for white and 700-850 for yellow. However from visual inspection it was noticed that many of the ceramic reflective elements had been partially shaved of, possibly by a snowplow. This may have affected the readings that were taken.

The second evaluation was conducted on May 14, 2002. During the summer of 2001, this experimental project had been inadvertently remarked as part of remarking the adjacent water based paint sections. Except for a single skip line, all of the Series 1200 paint had been remarked. The new paint was darker than Series 1200 paint and heavily worn. The new paint was more worn where it was placed on top of the Series 1200 paint than on adjacent pavement. Typically, 50% of the new paint remained on the surface of the Series 1200 paint. The Series 1200 paint appeared to be in good condition and very bright in daylight. Photo 5 shows the typical condition of the Series 1200 paint during the second annual evaluation.



Photo 5 - Series 1200 remarked with water based paint.

Reflective luminance readings were taken with the same testing device used for the first evaluation. The average reflected luminance (R_L) values of the markings in the test section are given in Table 4.

Reflected Luminance (R_L)				
Type	White		Yellow	
	Average	Std Dev	Average	Std Dev
3M Stamark™ 1200 - 4" *	186.3	37.5	68.9	16.1
Water Base - 4" *	196.7	12.9	67	2.7
Centerline Skip 3M Stamark™ 1200 - 4" *	164.5	38	N/A	N/A
Centerline Skip Tape	600.1	65.4	N/A	N/A

* Remarked the previous year with water based paint.

Table 4

A Series 1200 skip line had been missed during the remarking and the water based skip line was placed next to it. The Series 1200 skip line appeared bright and to be intact. On close inspection, many beads appeared to have come loose from the Series 1200 paint. The water based skip line was heavily worn. Photo 6 shows the condition of the skip lines. The average reflected luminance values were 94 for the Series 1200 paint and 131 for the water base paint.



Photo 6 - Left marking is water based paint and the right marking is Series 1200 paint. (Temporary marking placed previous to Series 1200 paint is visible on the left edge of Series 1200 line.)

Cost Comparison

The costs associated with each pavement marking can be seen in Table 5.

Paint Type	# of Units	Unit Price	Total
3M Stamark 1200 Series	12,685 LF	\$0.86	\$10,909.10
Water Based	12,685 LF	\$0.05	\$634.25
Difference			\$10,274.85
Centerline Skip Tape	22,400 LF	\$2.15	\$48,160.00

Table 5

Summary

The object of this experimental project was to determine if the 3M Stamark Liquid Pavement Marking Series 1200 is more durable and also more cost effective than the presently used water based paint. The experimental pavement marking was applied with a specially designed pavement-marking machine that would allow for placement of the two component liquid materials, glass beads and ceramic reflective elements.

The Series 1200 paint once applied is brighter than regular water base paint. However, the retroreflectivity test data of the first evaluation, proved to be significantly lower than the manufacturers initial reflectance range. This could be partly due to the ceramic reflective elements being shaved off, possibly by snowplows. The expected values should be around 1200-1400 for white and 700-850 for yellow. The average retroreflectivity value for the white Series 1200 was 391 and the white water base was 276. The average retroreflectivity value for the yellow Series 1200 was 269 and the yellow water base was 135.

This experimental project had been remarked in the summer of 2001 with a water based paint. The retroreflectivity data from the second evaluation in May 2002 cannot be considered representative of the performance of the Series 1200 paint. During the second evaluation, the Series 1200 paint appeared brighter than the water based paint in daylight.

The experimental section was chip sealed in August 2002 and all Series 1200 markings were obliterated.

Recommendation

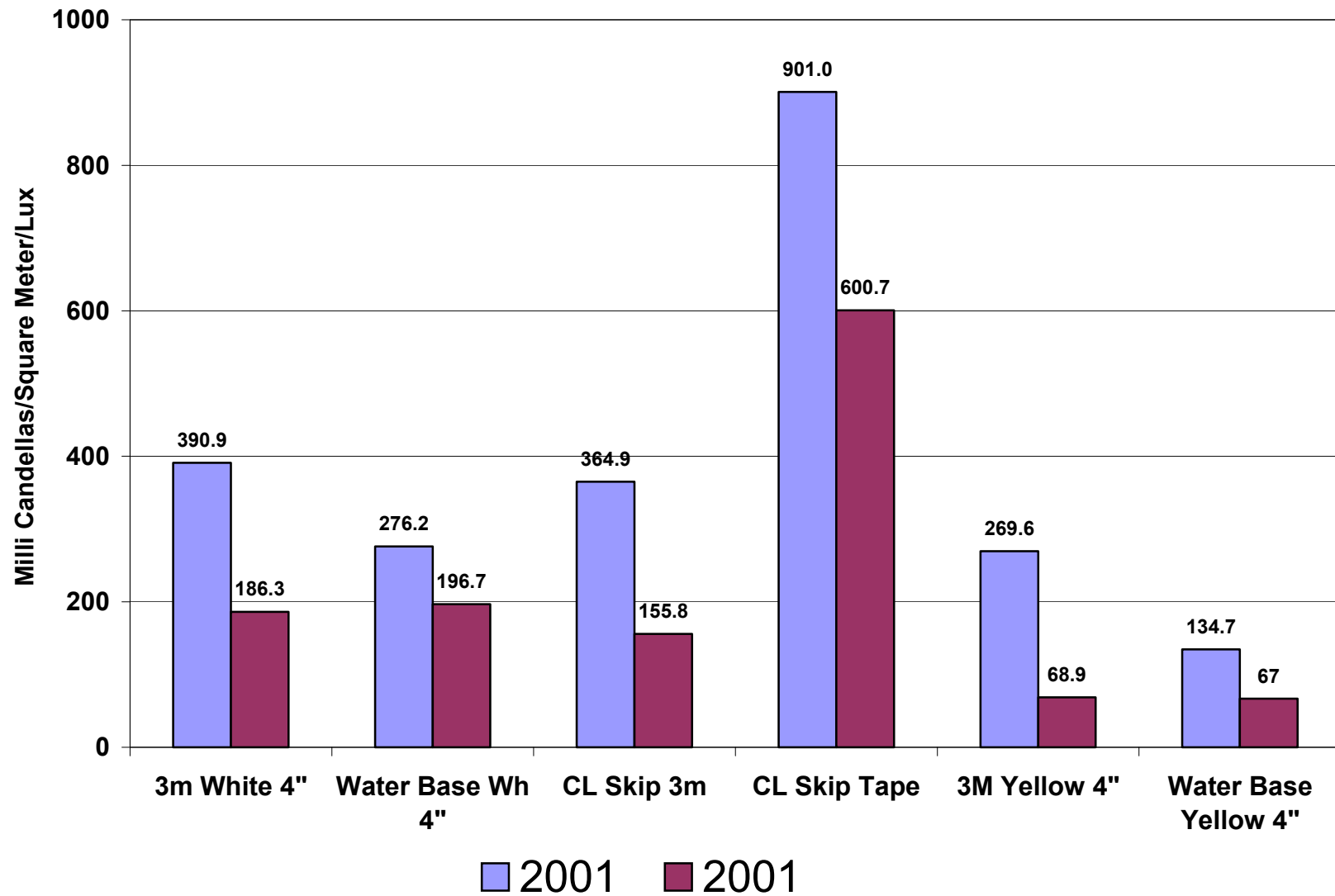
This project was remarked with a water based paint during the summer of 2001. The retroreflectivity data from the second evaluation isn't representative of the performance of the Series 1200 paint. Because this experimental study cannot accurately evaluate the performance of the Series 1200 paint, it will be discontinued. The experimental section was chip sealed in August 2002.

If there is still interest in evaluating Series 1200 paint, it is recommended that the experimental study be repeated at a new location.

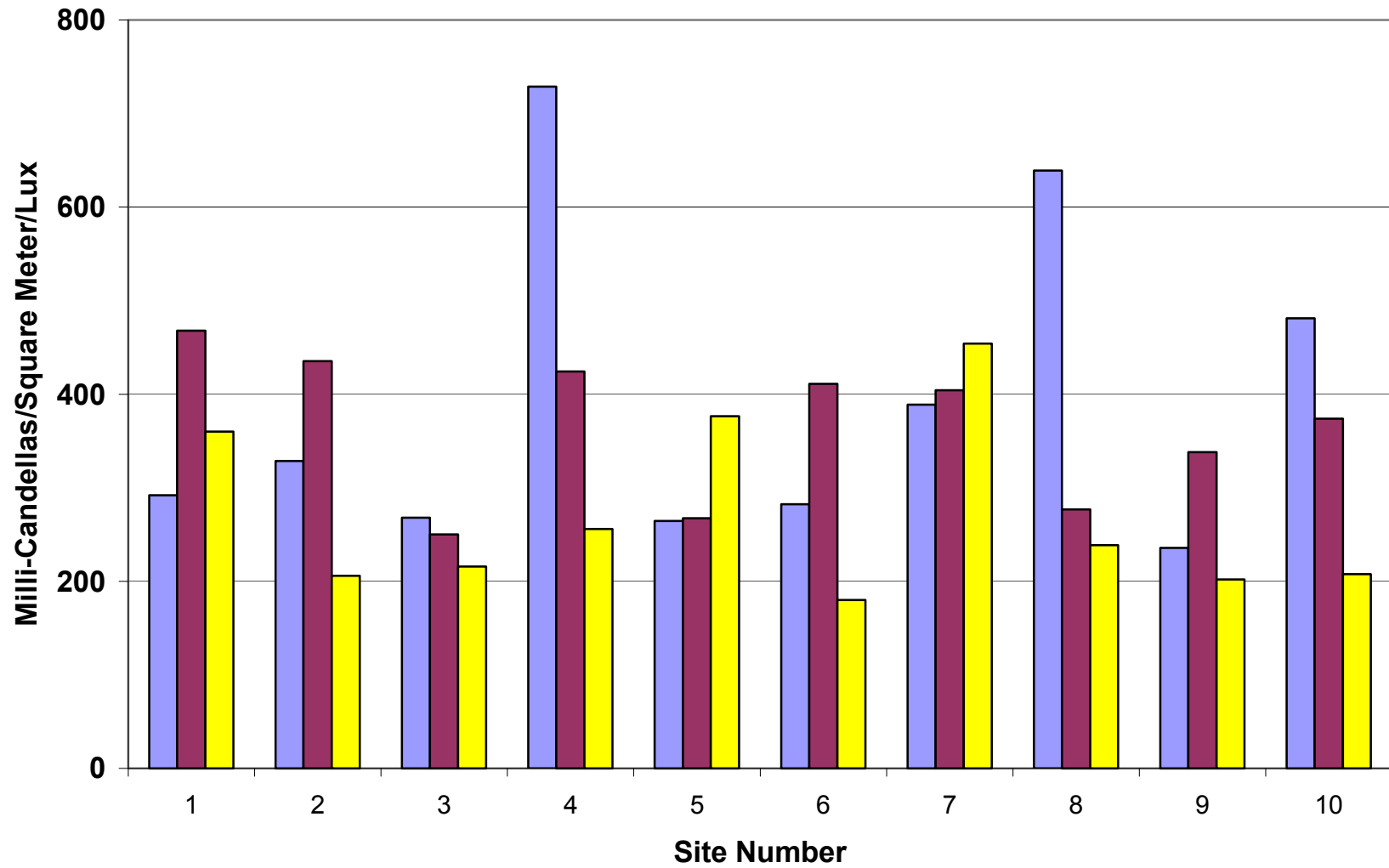
Appendix A

Average Retroreflectivity

30 Meter Geometry

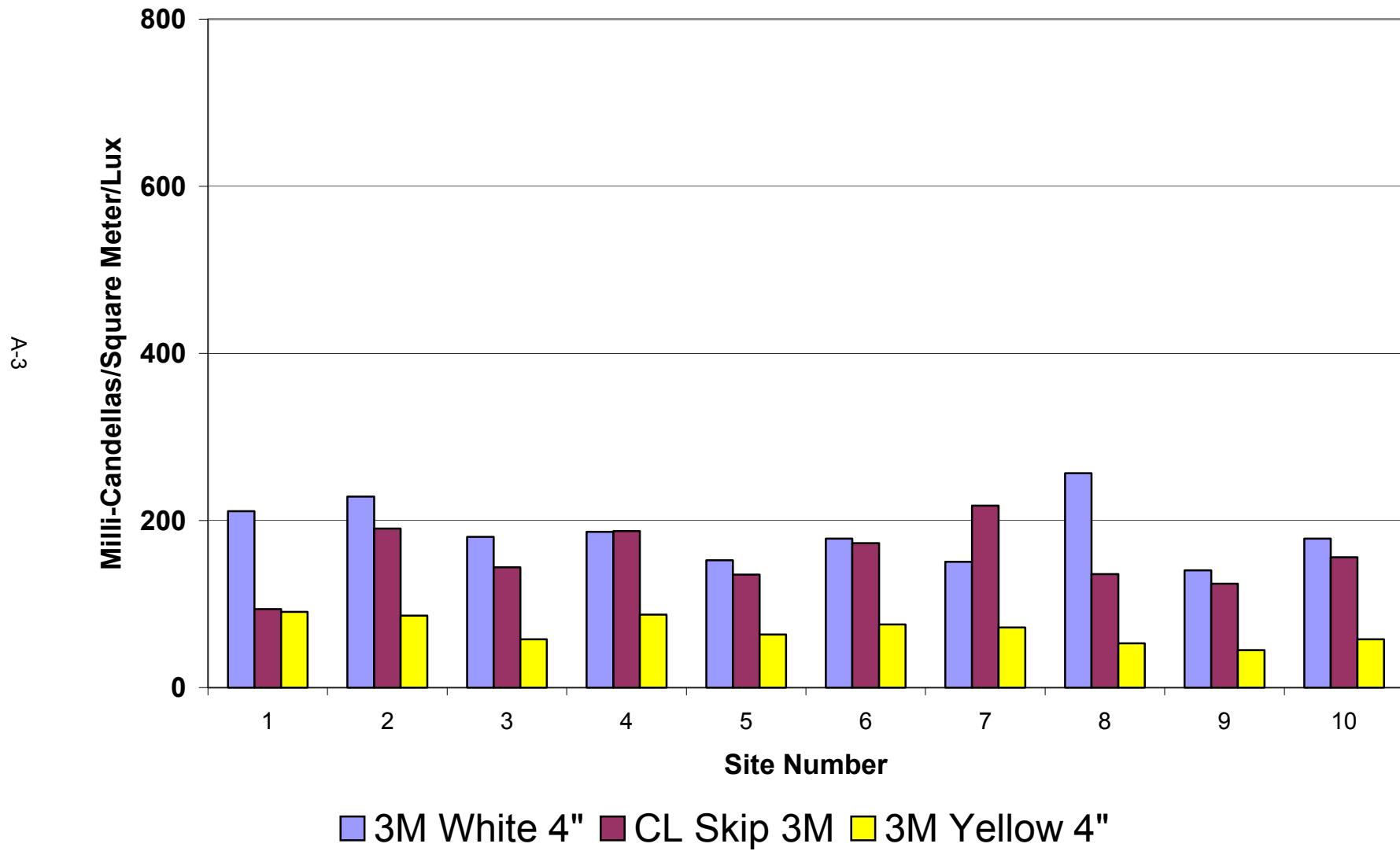


2001 Retroreflectivity



3M White 4" CL Skip 3M 3M Yellow 4"

2002 Retroreflectivity



Jan 11, 2001 & May 14, 2002

Equipment: LTL 2000

Site #1 (same as location A)

Start of 3M Striping

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	276	215	235	211	514	117		126	916	616	329	87	181	65
	314	212	248	193	515	77		138	919	529	444	93	102	66
	286	206	245	186	375	88		130	868	657	307	92	121	70
Average	292	211	242.7	196.7	468	94		131.3	901	600.7	360	90.67	134.7	67
STD	19.7	4.583	6.807	12.9	80.54	20.66		6.11	28.62	65.36	73.57	3.215	41.24	2.646

Site #2

10 skips from the start

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	398	239			340	126					181	85		
	330	241			483	191					210	87		
	258	206			483	254					226	86		
Average	328.7	228.7			435.3	190.3					205.7	86		
STD	70.01	19.66			82.56	64					22.81	1		

Site #3

10 Skips North

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	238	193			241	122					275	60		
	251	173			222	129					200	53		
	315	175			287	181					172	60		
Average	268	180.3			250	144					215.7	57.67		
STD	41.22	11.02			33.42	32.23					53.26	4.041		

Site #4

10 Skips North

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	683	227			526	179					371	80		
	706	174			434	188					115	84		
	797	158			313	195					282	98		
Average	728.7	186.3			424.3	187.3					256	87.33		
STD	60.29	36.12			106.8	8.021					130	9.452		

Site #5 (same as location B)

10 Skips North

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	275	168			237	128					372	67		
	278	141			298	143					326	59		
	240	148			267	135					431	65		
Average	264.3	152.3			267.3	135.3					376.3	63.67		
STD	21.13	14.01			30.5	7.506					52.63	4.163		

Site #6

15 Skips North

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	266	181			297	178					146	64		
	301	170			506	196					171	84		
	280	184			430	145					223	79		
Average	282.3	178.3			411	173					180	75.67		
STD	17.62	7.371			105.8	25.87					39.28	10.41		

Site #7

15 Skips North

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	406	143			399	228					308	80		
	406	165			508	209					459	71		
	354	144			306	216					595	65		
Average	388.7	150.7			404.3	217.7					454	72		
STD	30.02	12.42			101.1	9.609					143.6	7.55		

Site #8

skips Back of HWY 200

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	595	258	316		233	141					153	58		
	650	254	303		300	130					330	51		
	674	258	310		297	136					232	50		
Average	639.7	256.7	309.7		276.7	135.7					238.3	53		
STD	40.5	2.309	6.506		37.85	5.508					88.67	4.359		

Site #9

9 Skips North

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	228	145			245	114					242	46		
	249	141			408	118					245	47		
	230	135			361	141					119	42		
Average	235.7	140.3			338	124.3					202	45		
STD	11.59	5.033			83.9	14.57					71.9	2.646		

Site #10

10 Skips North

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
	493	180			248	191					261	53		
	452	182			457	141					158	58		
	498	173			416	136					204	62		
Average	481	178.3			373.7	156					207.7	57.67		
STD	25.24	4.726			110.7	30.41					51.6	4.509		

Total Averages

	3M		Water Base		3M		Water Base		Tape		3M		Water Base	
	White 4"		White 4"		CL Skip		CL Skip		CL Skip		Yellow 4"		Yellow 4"	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Average	390.9	186.3	276.2	196.7	364.9	155.8		131.3	901	600.7	269.6	68.87	134.7	67
STD	168.5	37.48	37.18	12.9	101.7	42.13		6.11	28.62	65.36	112.5	16.07	41.24	2.646

Appendix B

CHANGE: BF

ORDER NO: BC

CONTRACTOR: ANDERSON WESTERN, INC.

PC BOX 2315

BISMARCK, ND 58502

PROJECT: AC-NH-1-023-059.111

COUNTY: MCLEAN & BURLEIGH COUNTIES

FOR: GRADE, BLENDED BASE, HOT BIT PVT&INCLD.

ORIGINAL CONTRACT AMOUNT

\$ 6,482,947.97

DATE: 12/07/2000

SPEC CODE		ITEM OF WORK	UNIT	ORIG + OR -	- OR -	UNIT	INCREASE	DECREASE
NO	NO			PREVIOUS CHG				
				QUANTITY	QUANTITY	PRICE	AMOUNT	AMOUNT
ADDED CONTRACT ITEM								
PARTICIPATING (AC-NH FEDERAL FUNDS)								
762		88 3M SERIES 1200 PVT MARKING	LF	0.000	12,685.000	0.860	10,909.10	
NET INCREASE OR DECREASE TO DATE			98,406.31	PART	10,000.00	NON-PART	TOTALS	10,909.10
							NON-PARTICIPATING	0.00
							PARTICIPATING	10,909.10
DUE TO THIS CHANGE, THE CONTRACT TIME:								
IS NOT CHANGED.								

EXPLANATION OF CHANGE IN PLAN RECOMMENDED

If the Federal Funds authorized in the cost participation agreement with the local agency is exceeded and Federal Funds are not available for this change, the local agency will assume the total cost of this change order.

A TEST SECTION WAS REQUESTED BY MATERIALS AND RESEARCH FOR THIS TYPE OF PAVEMENT MARKING. THE PRICE IS NEGOTIATED. SEE ATTACHMENTS.

[Signature] 12-10-00

CONTRACTOR DATE

[Signature]

☒ Approval Recommended () Approved

PROJECT ENGINEER DATE

K-G-L 1-26-01 ASB 1-23-2001

() Approval Recommended ☒ Approved

DISTRICT ENGINEER DATE

CITY/COUNTY/OTHER OFFICIAL DATE

REPRESENTING

() Approved

REGION ENGINEER DATE

ANDERSON WESTERN

ANDERSON WESTERN, INC.
GENERAL HIGHWAY CONTRACTORS
P.O. Box 2319 Bismarck ND 58502
Telephone 701-222-3550 Fax 701-222-3516

5 December 2000

Bernie Southam. P.E.,
ND DOT
218 Airport Road
Bismarck ND 58504

State # AC-NH-1-083(058)111
Location: McLean & Burleigh Co. ND
AWI Project # 0002

Please find enclosed a letter from Traffic Safety Services regarding the above referenced project. The unit price for the Change Order for the 3M Series 1200 used is as follows:

TSS	12,685 LF	@ 0.780 =	9,894.30
Prime Markup	12,685 LF	@ 0.078 =	989.43
Total		0.858 =	10,883.73

Cordially.

Linda Phillips
Corporate Secretary

Enclosure

2000



TRAFFIC SAFETY SERVICES, INC.

A Division of

United Rentals

*The Sign of
Service!*

Bismarck Office: 1507 Continental Ave • Bismarck, ND 58504 • 701-258-4770 • Fax 701-258-8002

December 1, 2000

RE:AC-NH-1-083(058)111

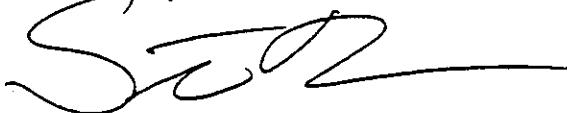
Rodney Rodeman
Anderson Western
PO Box 2319
Bismarck, ND 58502

Dear Rodney Rodeman,

After a conference with Bernie Southam from the ND DOT regarding pricing for 3M Series 1200 that was applied on the northern-most mile of your project near Washburn, it came to my attention that no amount has been set for this particular change order. Our price for the 12,685 LF that was applied will be \$0.78/LF.

If you have any questions let me know.

Sincerely,



Steve Hsu
Pavement Marking Manager
United Rentals Highway Technologies

